

**ADDENDUM #1
TO SPEC. 03-109**

**MICROWAVE ASSISTED ACID
DIGESTION APPARATUS**

Addendum #1 to Spec. 03-109 for Microwave Assisted Acid Digestion Apparatus for Lincoln Wastewater System, bids to be opened on Wednesday, April 9, 2003 at 12:00 noon.

Attached is the Standard Methods for the Examination of Water and Wastewater (Attachment 1) as stated in 3.2.3 of the Special Provisions.

All other terms and conditions to remain unchanged.

Dated this 3rd day of April, 2003.

Purchasing Department

Tom Kopplin
Assistant Purchasing Agent

Standard Methods for the Examination of Water and Wastewater

3030 K. Microwave-Assisted Digestion

3. Calibration of Microwave Unit

NOTE: For microwave units equipped with temperature feedback electronic controls, calibration of the microwave unit is not required provided performance specifications can be duplicated.

For cavity-type microwave equipment, evaluate absolute power (watts) by measuring the temperature rise in 1 kg water exposed to microwave radiation for a fixed time. With this measurement, the relationship between available power (W) and the partial power setting (%) of the unit can be estimated, and any absolute power in watts may be transferred from one unit to another. The calibration format required depends on type of electronic system used by manufacturer to provide partial microwave power. Few units have an accurate and precise linear relationship between percent power settings and absorbed power. Where linear circuits have been used, determine calibration curve by a three-point calibration method; otherwise, use the multiple-point calibration method.

a. Three-point calibration method: Measure power at 100% and 50% power using the procedure described in § 3c and calculate power setting corresponding to required power in watts as specified in the procedure from the two-point line. Measure absorbed power at the calculated partial power setting. If the measured absorbed power does not correspond to the calculated power within ± 10 W, use the multiple-point calibration method, § 3b. Use this point periodically to verify integrity of calibration.

b. Multiple-point calibration method: For each microwave unit, measure the following power settings: 100, 99, 98, 97, 95, 90, 80, 70, 60, 50, and 40% using the procedure described in § 3c. These data are clustered about the customary working power ranges. Nonlinearity commonly is encountered at the upper end of the calibration curve. If the unit's electronics are known to have nonlinear deviations in any region of proportional power control, make a set of measurements that bracket the power to be used. The final calibration point should be at the partial power setting that will be used in the test. Check this setting periodically to evaluate the integrity of the calibration. If a significant change (± 10 W) is detected, re-evaluate entire calibration.

c. Equilibrate a large volume of water to room temperature ($23 \pm 2^\circ\text{C}$). Weigh 1 kg water ($1000 \text{ g} \pm 1 \text{ g}$) or measure ($1000 \text{ mL} \pm 1 \text{ mL}$) into a plastic, not glass, container, and measure the temperature to $\pm 0.1^\circ\text{C}$. Condition microwave unit by heating a glass beaker with 500 to 1000 mL tap water at full power for 5 min with the exhaust fan on. Loosely cover plastic container to reduce heat loss and place in normal sample path (at outer edge of rotating turntable); circulate continuously through the microwave field for 120 s at desired power setting with exhaust fan on as it will be during normal operation. Remove plastic container and stir water vigorously. Use a magnetic stirring bar inserted immediately after microwave irradiation; record maximum

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temperature within the first 30 s to $\pm 0.1^\circ\text{C}$. Use a new sample for each additional measurement. If the water is reused, return both water and beaker to $23 \pm 2^\circ\text{C}$. Make three measurements at each power setting. When any part of the high-voltage circuit, power source, or control components in the unit have been serviced or replaced, recheck calibration power. If power output has changed by more than $\pm 10\text{ W}$, re-evaluate entire calibration.

Compute absorbed power by the following relationship:

$$P = \frac{(K) (Cp) (m) (\Delta T)}{t}$$

where:

- P = apparent power absorbed by sample, W,
- K = conversion factor for thermochemical calories sec^{-1} to watts (4.184),
- Cp = heat capacity, thermal capacity, or specific heat ($\text{cal g}^{-1} ^\circ\text{C}^{-1}$) of water,
- m = mass of water sample, g,
- ΔT = final temperature minus initial temperature, $^\circ\text{C}$, and
- t = time, s.

For the experimental conditions of 120 s and 1 kg water (Cp at $25^\circ\text{C} = 0.9997$), the calibration equation simplifies to:

$$P = (\Delta T) (34.85)$$

Stable line voltage within the manufacturer's specification is necessary for accurate and reproducible calibration and operation. During measurement and operation it must not vary by more than $\pm 2\text{ V}$. A constant power supply may be necessary if line voltage is unstable.